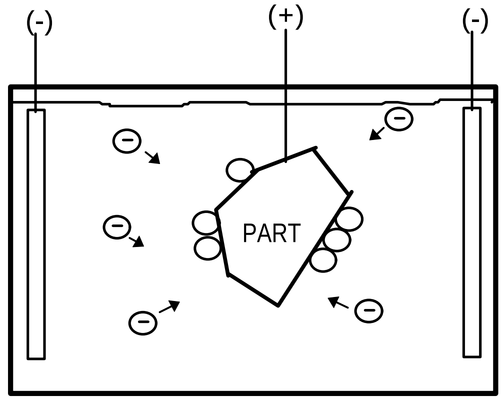
Applied Technology: E-Coat



Concept

Also known as electrodeposition, electrocoating, electropaint, ELPO, and electrophoretic. E-coat applies paint to parts using a process analogous to electroplating. The ionic components of the paint (resins, pigments, solvent, and additives) migrate to the opposite charged part in a water bath. Water migrates away from the part, leaving the coating. The thickness of the coatings is dependent on the voltage applied and part deposition time. As the coating builds up, it insulates the part from further build up and the paint moves to the remaining bare area providing a highly uniform layer. E-coat an be either cathodic or anodic. Almost any type of paint can be e-coated. Almost any conductive substrate can be e-coated.

Applications

- Polyurethane, Lacquer, Acrylic, Epoxy and other commonly used coating systems (clear, tinted, or opaque)
- Primer coating
- Automotive, marine, appliances, office equipment, electrical enclosures
- Any conductive substrate
- Barreled parts

Technologies Replaced

- Conventional Spray
- High Pressure - Low Volume (HPLV)
- Electrostatic, Airless, Rotating Bell
- Powder
- Ultraviolet and Electron Beam Cure
- Roll Coat, Vacuum Coat
- Dip
- Autodeposition

Wastes Reduced

- Raw Materials
- Clean up
- Rework
- Overspray
- Make Up Air
- Volatile Organic Compounds (VOCs)
- Hazardous and Toxic
- Heavy metals (in coatings)

Potential in Manufacturing

Indust	*SIC*	*Pot*	*Indust*	*SIC*	*Pot*	*Indust*	*SIC*	*Pot*	*Indust*	*SIC*	*Pot*	*Indust*	*SIC*	*Pot*
Food	20	LOW	Lumber	24	LOW	Chem	28	LOW	Stone	32	LOW	**Elect**	**36**	**HI**
Tobac	21	LOW	**Furn**	**25**	**HI**	Petrol	29	LOW	Pmetal	33	LOW	**Transp**	**37**	**HI**
Textile	22	LOW	Paper	26	LOW	Rubber	30	LOW	**MetFab**	**34**	**HI**	Instr	38	MED
Apparel	23	LOW	Printing	27	LOW	Leather	31	LOW	Mach	35	MED	Misc	39	MED

Credits: Steve Hillenbrand, Tennessee Valley Authority; Jack Lofstrom, Clearclad Coatings, Inc.; Dave Myers, Milbank Systems

E-Coat *continued*

Technology Advantages

- Excellent film thickness control
- Coverage in difficult locations (good throwing power) and on complex parts
- Superior corrosion protection
- Low fire hazard
- Very thin coats possible
- Low or no VOC and HAPs emissions
- Coating efficiencies of 85 - 95% possible
- Low coating cost/part
- Low labor cost
- High production speeds possible

Technology Disadvantages

- Substrate must be conductive
- High initial capital investment
- High raw material cost per concentrated unit
- More controls required (close tolerances on operating conditions)
- Requires high production to be cost effective
- Coating thickness typically 0.4 to 1.5 mils
- Limited colors, color changes

Typical Costs

Capital Costs	O & M Costs (per sf per mil film thickness)	Potential Payback
high: $500k - $10,000k +	material =$0.025 - $0.035 e-coat power = $0.01 - $0.02 overall = $0.08 - $0.10* maintenance is critical but low *includes labor, prep and cure	less than 1-year

Installations

Case A - A typical e-coat system consists of the following operations: 1) preparation/cleaning, 2) iron or zinc phosphating (optional), 3) e-coat tank, and 4) curing. Between each of the operations are one or more rinse steps. The rinse steps can use tap water, deionized water, or recycled permeate depending on where the step is in the process. E-coat operations can be essentially closed loop systems with judicial system design and by including ultrafiltration and reverse osmosis to clean up wastewaters for reuse.

Case B - A company produced two small fuel injector housing components with very tight tolerances both before and after mating. The coating was required to have high integrity and fall between 0.4 and 0.5 mil in thickness. A defect could “jam up” the assembly equipment.

An e-coat system was designed and installed that produces 12,000,000 parts per year at costs below the company’s original estimate. [“Electrocoat Meets Challenges of Unusual Parts”, by Lyle Gilbert of MetoKote Corp, Products Finishing, August 1995, pages 51,52]-

Major Vendors

E-Coat

BASF Corporation
(coating material)
26701 Telegraph Road
Southfield, MI 48034
(800) 347-2273, ext 5774 or 5781

ClearClad Coatings, Inc
(coating material)
16910 S. Lathorp Avenue
Harvey, IL 60426
(708) 596-0001

Crown Group
(coating job shop - out sourcing)
2111 Walter Reuther Drive
Warren, MI 48091
(810) 575-9800

Behr Systems
(equipment)
2469 Executive Hills Boulevard
Auburn Hills, MI 48326
(248) 745-8500

Eisenmann Corporation
(equipment)
150 East Dartmoor Drive
Crystal Lake, IL 60014
(815) 455-4100

Electrocoat Association
(trade association)
6915 Valley Avenue
Cincinnati, OH 45244
(800) 950-8977 (ask for Electrocoat Association)

Enthone-OMI, Inc.
(coating material)
21441 Hoover Road
Warren, MI 48089
(800) 521-4267

Koch Electrocoating Systems
(equipment)
10 S. Eleventh Street
Evansville, IN 47744
(812) 465-9600

Lilly Industries
(coating material)
733-T S. West Street
Indianapolis, IN 46225
(800) 626-0519

MetoKote Corporation
(coating job shop - out sourcing)
1340 Neubrecht Road
Lima, OH 45801
(419) 227-1100

Milbank Systems, Inc.
(equipment)
1925 Bedford Road
North Kansas City, MO 64116
(816) 472-4674

PPG Industries, Inc.
(coating material)
151 Colfax Street
Springdale, PA 15144
(800) 774-3262

Therma-Tron-X (TTX), Inc.
(equipment)
1155 S. Neenah Avenue
Sturgeon Bay, WI 54235
(630) 443-1020 (sales office)

The Valspar Corporation
(coating material)
1200 Roosevelt Road, Suite 202
Glen Ellyn, IL 60137
(630) 889-8099

This list of vendors of the indicated technology is not meant to be a complete or comprehensive listing. Mention of any product, process, service, or vendor in this publication is solely for educational purposes and should not be regarded as an endorsement by the authors or publishers.

Index to DOCUMENTS

E-COAT

What is E-coat? - A Brief History of E-coat, Clearclad vendor documentation, (reference: www.clearclad.com/more.html - 3/31/98)

Electrocoat: The Next Step, Cindy Goodridge, the Electrocoat Association, Products Finishing, August 1997
(reference: www.gardnerweb.com/pf/magazine/articles/089702.html - 3/31/98)

VOC Facts Detail, Clearclad vendor documentation,
(reference: www.clearclad.com/misc.html - 4/13/98)

The Electrocoat Process, PPG Industries vendor documentation,
(reference: www.powercron.com/EProcess.html - 4/13/98)

Other documents can be found at the

Electrocoat Association publications web site:

http://www.electrocoat.org/resources.html

WHAT IS E-COAT? -- A BRIEF HISTORY OF E-COAT

ORIGINATION

Even though E-coat has been with us since the 1930, it is mainly due to large interest and capital investment in the 70's by the automobile industry for primers that made it popular. Since then the technology has found its way into the more decorative and functional (non primer) single coat application like CLEARCLAD.

TIMING OF E-COAT DEVELOPMENT

1940's - Experimentation into electodepositing phenolic resin coatings onto electrical wire on a continuous basis.

1950's - Full scale development of electrodeposition of anti-corrosive paint primers onto automobile bodies.

1960's -- Development of exterior durable, light colored electropaint resin systems suitable for domestic appliances, architectural aluminum etc. Principle technology to this time - anodic

1970's -- Cathodic technology displaces anodic as the principle system in the automobile industry. Such systems are adapted for small scale use in the electroplating industry (circa 1978).

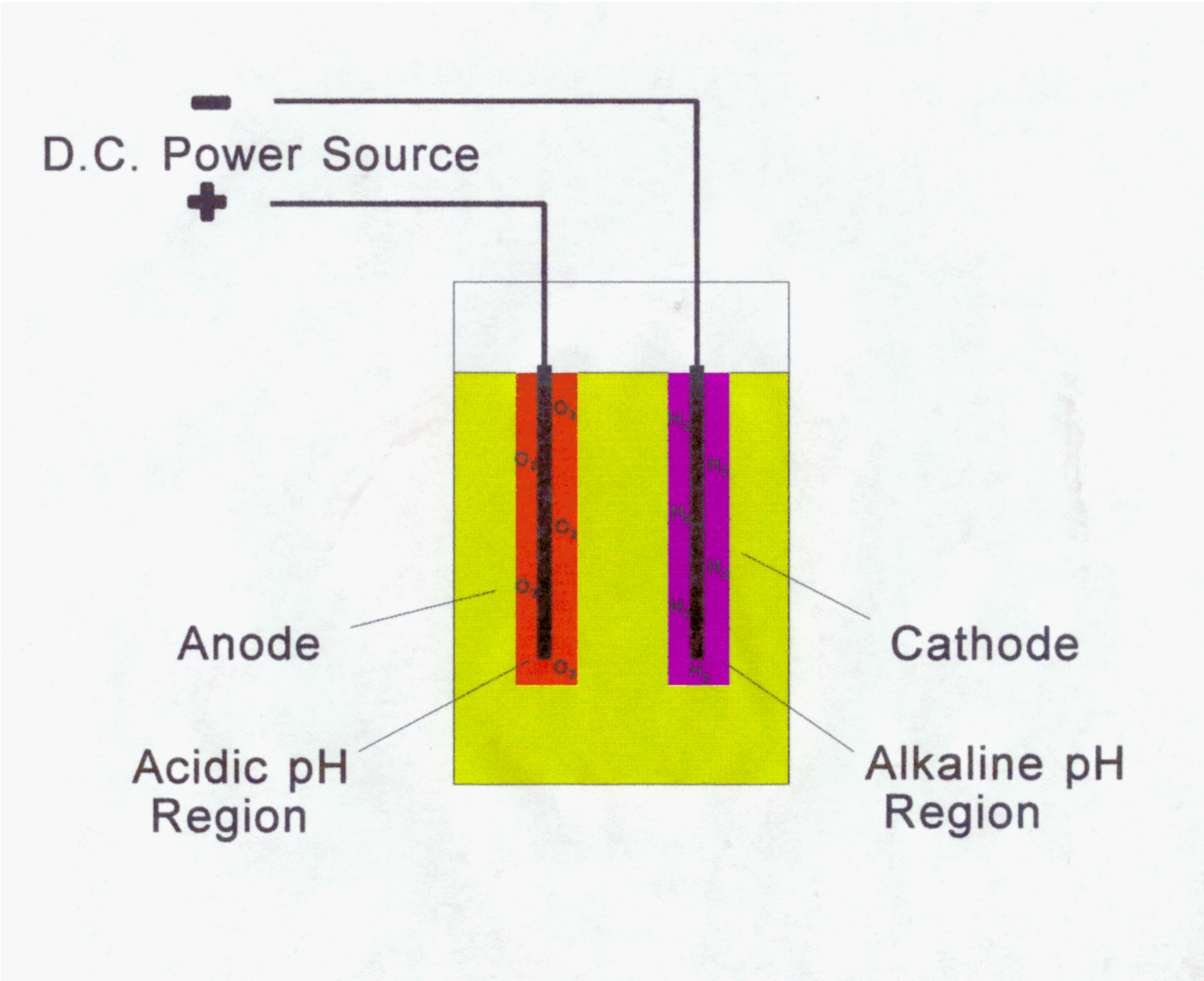
1980's -- Technology continues to evolve as protective coatings for the metal finishing industry.

SO, WHAT IS E-COAT?

PROCESS MECHANISM

E-coat is an emulsion of organic resins and de-ionized water, which is in a stable condition. The e-coat solution also is comprised of some solvent and ionic components. When a D.C. voltage is applied across two immersed electrodes, the passage of current is accompanied by electrolysis of water. This results in oxygen gas being liberated at the anode (positive electrode) and hydrogen gas liberated at the cathode (negative electrode). The liberation of these gases disturbs the hydrogen ion equilibrium in the water immediately surrounding the electrodes. This results in a corresponding pH change and this in turn de-stabilizes the paint components of the solution and they coagulate onto the appropriate electrode. - Cathodic electropaints are stable except at high (alkaline) pH. Anodics are stable except at low (acid) pH Electrolysis of water causes the cathode to become alkaline and the anode to become acid.

Electrolysis of Water



Electrophoresis is a well documented process whereby electrically charged particles in a conductive medium will migrate to the electrode bearing the opposite charge under the influence of D.C. voltage. Although many technical descriptions of electropaint ascribe electrophoresis to the deposition process it is not the predominant mechanism. However, it is very common to refer to electropaint as "Electrophoretic".

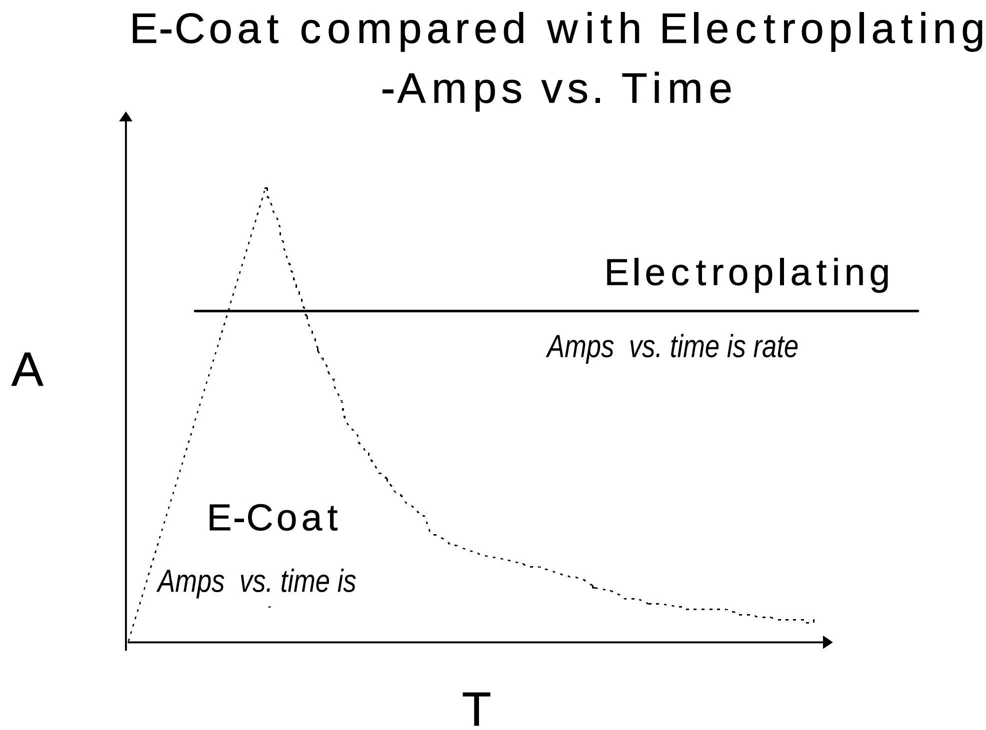
HOW IS IT APPLIED?

APPLICATION

An unfinished product is immersed in a bath containing the electrophoretic paint emulsion, and then an electric current is passed through both the product and the emulsion. The paint particles that are in contact with the product adhere to the surface, as described in the above mechanism, and build up an electrically insulating layer. This layer prevents any further electrical current passing through, resulting in a perfectly level coating even in the recessed parts of complex-shaped goods. The product is then removed from the paint bath and baked in an oven.

HOW DOES THIS COMPARE TO ELECTROPLATING?

Due to the insulating nature of the deposit as described above, it is possible to accurately control the thickness over the part. Whereas with plating and anodizing thickness is controlled by amp/time relationship;



With e-coat the thickness is controlled by voltage. Time is not as critical as once the part is coated and insulated, no more coating will take place. Depending on surface area and complexity of the parts, most coating is easily accomplished with 2 minutes. This highlights one of the big equipment differences. Plating and anodizing require low voltage and high amperage rectification. E-coat requires high voltage and low amperage (1 sq. ft. draws 1.5 amps max) rectification.

Excerpts from

Electrocoat: The Next Step

The advantages of electrocoating and its new Association...

By Cindy J. Goodridge
Executive Director
The Electrocoat Association
Cincinnati, Ohio

Electrocoat technology can hardly be called new. Since its commercialization in the early 1960's as an automobile body primer, this technology has grown and matured to become the "Environomic" (environmentally friendly and economically efficient) process it is today. The electrocoat industry today serves much more than the automotive market. Engineers for an array of products have opted for electrocoat over other liquid and powder coating processes because of the tremendous advantages electrocoat has, particularly in the areas of application techniques, efficiency, automation and environmental compliance.

Types of electrocoat. Electrocoat paint systems use electrical current to deposit paint onto a part. The basic principle of electrocoating is that materials with opposite electrical charges attract. An electrocoat system applies a specific charge to a part that is immersed in a bath of paint particles with an opposite charge. The paint particles are drawn to the part, and paint is deposited on the part, forming an even, continuous film over every surface until the coating reaches the desired thickness. At that thickness, the film encases the part, attraction stops and electrocoating is complete. Depending on the polarity of the charge, electrocoating is classified as either anodic or cathodic.

Anodic. In anodic electrocoating, the part to be coated is the anode, having a positive electrical charge. This attracts the negatively charged paint particles in the paint bath. The main use for products that use this type of electrocoat is interior or moderate exterior environments. Anodic coatings are economical systems that offer excellent color and gloss control.

Cathodic. In cathodic electrocoating, the workpiece is given a negative charge, which attracts the positively charged paint particles. Cathodic coatings are high-performance coatings with excellent corrosion resistance and can be formulated for exterior durability.

Advantages of Electrocoat. One advantage of electrocoat is application. It provides total coverage of complex-shaped parts. It coats all recessed areas and sharp edges. It provides excellent film uniformity without sags, runs or drips.

Electrocoating allows for precise film build control. Thickness is easily controlled using simple voltage adjustment. Also, parts can be assembled prior to coating. Electrocoating also has economical advantages, including total automation so no direct labor is required. It provides for high productivity, allowing dense and non-uniform line loading. Parts pass very quickly through the production line, resulting in lower unit costs. The process has high transfer efficiency, approaching 100 pct. Electrocoating has low energy requirements since no drying or flash-off time is required. Minimal exhaust and air make-up are needed as well as reduced cure times and temperatures.

Electrocoat systems are low maintenance with minimal hook cleaning and no "booth" maintenance. Insurance rates are minimal because there are no specific fire or health hazards.

There are a number of environmental advantages to electrocoating as well. Electrocoating emits low or zero VOCs and HAPs. Operators are not required to wear any special personal protection. The system is totally enclosed. The process produces minimal solid waste since it is a closed-loop system, which minimizes water loss. Since it is a waterborne system, fire hazards are reduced.

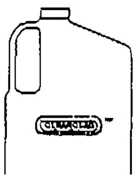
End Use	**Properties Added By Electrocoat**
Agriculture Equipment	High Gloss, Color Control, Weatherability, Corrosion Resistance
Appliance	Corrosion and Stain Resistance, Color Control
Automotive	Corrosion and Chip Resistance, Weatherability
Automotive Components	Corrosion, Chemical and Chip Resistance
Containers	(Can Coatings) Barrier and Chemical Resistance, FDA-Approved, No Effect on Flavor
Electrical Switchgear	Corrosion Resistance and U.L. Approval
Fasteners	Corrosion and Edge Coverage
Heating, Ventilation, and Cooling	Corrosion Resistance, Color Control, and Weatherability
Laboratory Furniture	Chemical, Stain, and Corrosion Resistance, Color Control
Lawn and Garden	Corrosion Resistance and Weatherability
Printed Circuit Boards	Edge Coverage and Hardness
Shelving and Furniture	Color Control, Hardness, and Stain Resistance
Wheels	Corrosion and Chip Resistance, Weatherability

Learn more about electrocoating and the new Electrocoat Association by contacting The Electrocoat Association, Cindy J. Goodridge, Executive Director, 6915 Valley Avenue, Cincinnati, OH 45244; telephone 1-800-950-8977 or 513-527-8977; Fax 513-527-8950.

For full text of this article on the Internet, the URL is: www.gardnerweb.com/pf/magazine/articles/089702.html

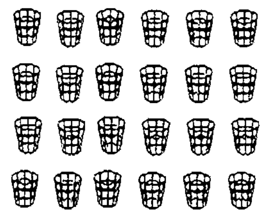
The CLEARCLAD VOC Facts Detail

1 Lb. of VOCs
are released -to
atmosphere or
after burning



1 Gallon of ClearClad@
concentrate, containing
4 Lbs. VOCs, is dlluted with
4 gallons of DI Water and
added to coating solution

Coated parts exit
coating tank to be
cured



1 Gallon Concentrate
Contalns:
Resin 4.0 lbs.
A250 1.0 lb.
A264 3.0 lbs.

ClearClad ®
Coating Tank

Curing

Deposited Material
Contains:
Resin 4.0 lbs,
A264 0.4 lbs.
A250 0.6 lbs.

Non-Deposlted material
Contaln~Permeate)

Water; 32 lbs.
A264 2.6 lbs.
A250 0.4 lbs.

Permeate Removed from
Coating System to Effluent

The Leader in E-Coat **Technology**

18970 South Lathrop Avenue
Harvey, IL 80425

Tel: (708) ***596-0001***
Fax: (708) ***596-0734***

file: CCVOCRVC.GED

1) General

In the use of organic coatings, most often these materials contain some form of Volatile Organic Compounds (VOCs). VOC abatement demands reduction of the photochemlcal effects of volatile organics. Such compounds are generally the solvent content of these materials (typlcally 3.0-4.0 Ibs/gallon for solvent based lacquers). Release of these solvents to the environment creates ozone by ths following reaction.

A) Solvent + Oxygen + Sunlight → Carbon Dioxide + **Water + OZONE**

One method of handling the VOC problem is to capture the VOCs released, in the flue for example, before they are released to the atmosphere, and flame-burn them to stop their release.

B) Solvent + Oxygen + Combustion → Carbon Dioxide + Water

Elimination of all VOCs would be ideal, however, impractical. Practical reduction of VOC emmissions to the environment Is available through the use of ClearClad E-Coating techniques. A large portion of the VOC content stays in the bath and is removed as permeate solution In proportlon to concentrate additlons to the coating bath. Since these VOCs are dissolved in the permeate solution, **their** further dissolution with water effluent, to low levels, allows their destruction by the following reactlon.

C) Solvent + **Oxygen +** Dlsoived **Air, Bacteria, etc,** → **Carbon Dloxide + Water**

One can see that we now have a large reduction of VOCs released to the atmosphere (or after burning).

Not to be overlooked are the significant additional VOC emisslon reductions that are achieved with ClearClad coating techniques. These are due to uniform deposit thickness and no overspray losses, ClearClad E-Coating techniques deposit a uniform thickness in the coating tank which can be easily controlled in the 5-40 micron range without any ovetspray, typical of spray application techniques, i.e. the material that misses the object being coated and just goes up the flue. Because of this, the number of parts being coated per gallon of coating material goes up dramatically. Typlcally, 10 times (see case study) bringing overall VOC reduction up into the 92% - 97% area against the same parts coated with solvent based lacquers using spray application techniques.

2) Case Study - A polisher/lacquerer provides their service on bath tub spouts (approximately 45 sq. in.). After polishing, for protectlon, using conventional spray lacquer techniques they are able to lacquer 400 pieces/gallon of lacquer containing 3.5 Ibs/gallon of VOC material (at least 2.5 Ibs. of which will be released). This low output of coated parts per gallon of material is caused by uneven coating thickness and overspray losses.

These same parts, coated using ClearClad E-Coating techniques at a 15 microns thickness (0.6 mils) use only one gallon of ClearClad concentrate to coat 3950 pieces, almost a ten-fold increase in output of coated parts.

Using conventional lacquering techniques, 400 pieces were coated releasing apptoxlmately 2.5 Ibs. of VOCs, or 160 pieces per lb. of VOC materlal released. Using ClearClad E-Coat, 3950 pleoes were coated releasing only 1 lb. of VOCs, or 3950 pieces per lb. of VOC material released. Overall, a 96% reduction of VOCs released per unit coated. It's simple. no overspray, uniform thickness and less VOC available for possible release.

[Case study data courtesy of Baron & Young, Inc.. Bristol, CT)

3) Note: The nomenclature A250 and A264 are solvent based components of ClearClad concentrates.

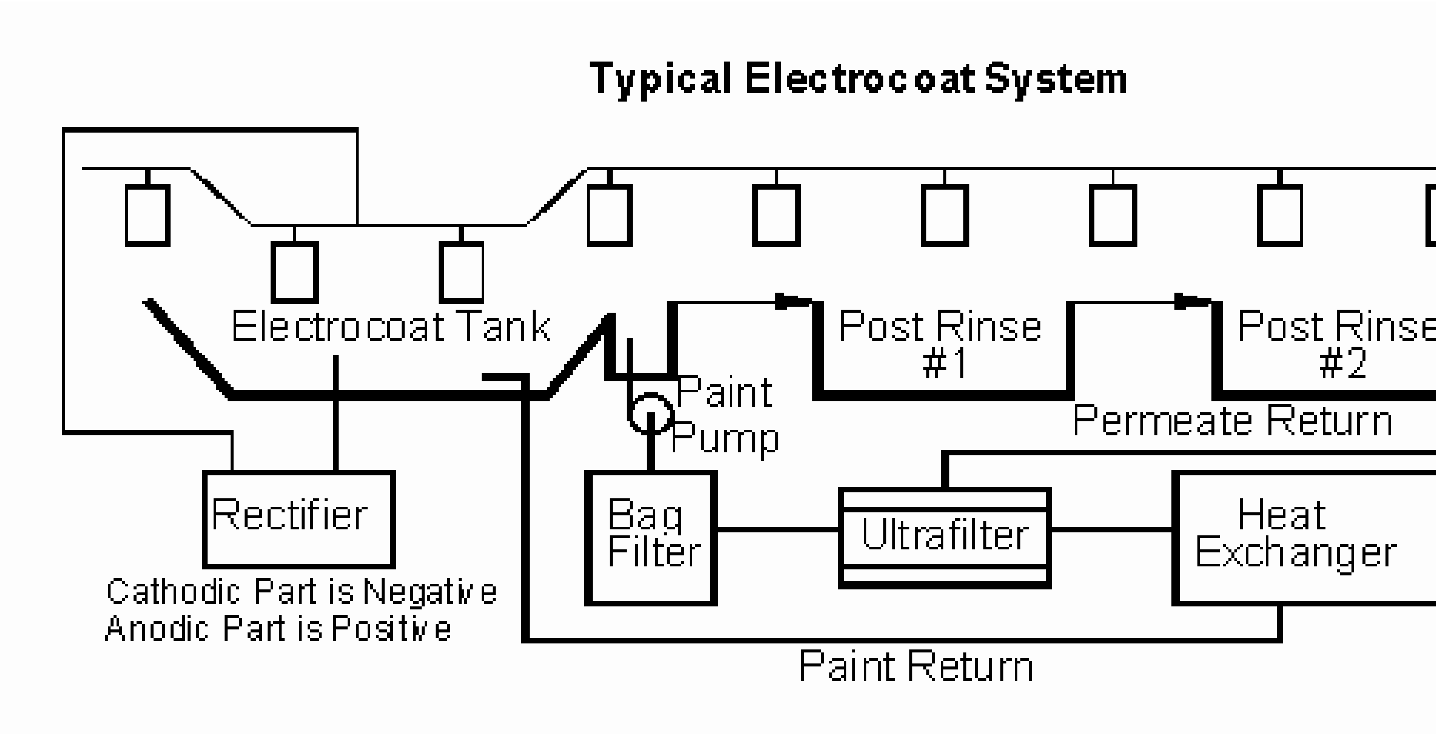
76910 ***South*** Lafhrop **Avenue**
Harvey, IL **60426**

Tel: (708 596-OOOf
Fax: (708 596-0734

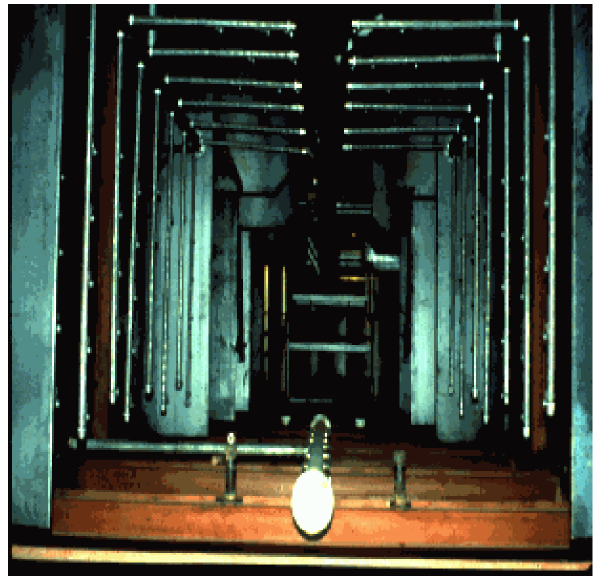
From PPG web site (www.powercron.com):

The Process of Electrocoat

reprinted with permission from PPG Industries, Inc.

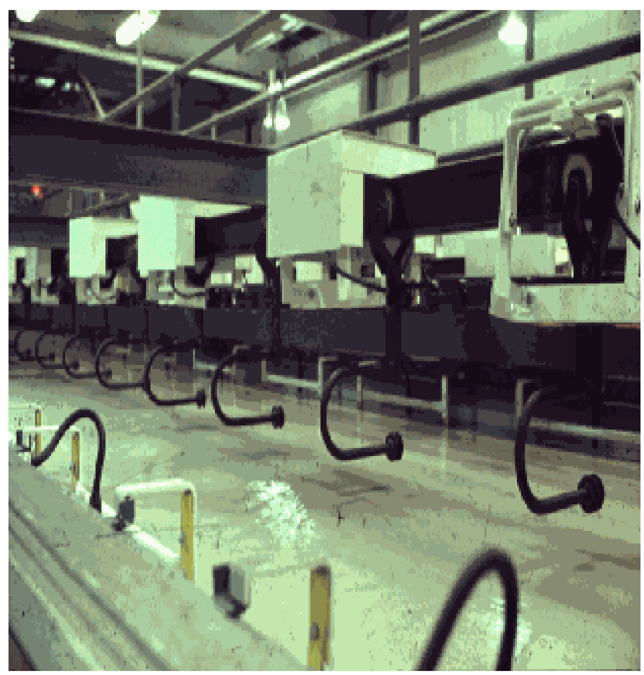


Pretreatment



The pretreatment section is where the metal surface is cleaned and phosphated to prep the part for electrocoating. Cleaning and phosphating are essential in achieving the performance requirements desired by the end user. Iron and zinc phosphate are common materials used in pretreatment systems. Spray and immersion stages can both be utilized in this section.

Electrocoat Bath



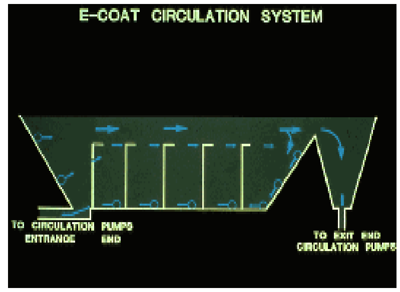
The electrocoat bath consists of 80-90% deionized water and 10-20% paint solids. The deionized water acts as the carrier for the paint solids which is under constant agitation. The paint solids consists of resin and pigment. Resin is the backbone of the final paint film and provides corrosion protection, durability, and toughness. Pigments are used to provide color and gloss.

Electrocoat Process - Ancillary Equipment

Rectifier

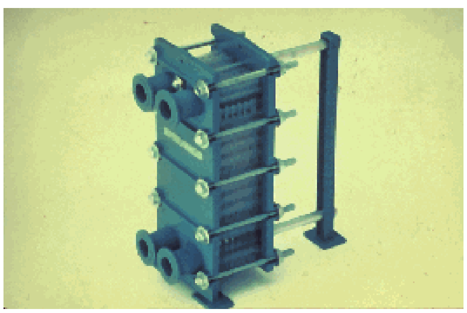
The rectifier supplies the DC electrical charge to the bath so coat-out can occur.

Circulation



Circulation pumps maintain proper paint mix uniformity throughout the electrocoat bath.

Heat Exchanger



The heat exchanger controls the temperature of the paint bath.

Filter

Tank filters remove dirt particles that are introduced into the paint system.

Ultrafilter

Ultrafilters produce permeate for rinsing and allow for recovery of paint solids.

Post Rinses

During the electrocoat process, paint is applied to a part at a certain film thickness, regulated by the amount of voltage applied. Once the coating reaches the desired film thickness, the part insulates and the coating process slows down. As the part exits the bath, paint solids cling to the surface and have to be rinsed off to maintain efficiency and aesthetics. The excess paint solids are called "drag out" or "cream coat". These post rinses are returned to the tank to create application efficiency above 95%.

Bake Oven

After exiting the post rinses the coated part enters the bake oven. The bake oven crosslinks and cures the paint film to assure maximum performance properties. Bake schedules range from 180ºF to 375°F at twenty minutes metal temperature depending on the technology being applied.

This information is designed to help you determine **potential** applications for the technology. You are encouraged to contact one of the listed vendors or a consultant for details and pricing.

For reprints write to:
TVA Industrial Waste Reduction
400 West Summit Hill Drive
Knoxville, TN 37902-1499

E-Mail:
sjhillenbrand@tva.gov

Web Site:
www.tva.gov/orgs/iwr/iwrhome.htm (this publication is available in Full Text)

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